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Review Article
Medicinal Applications, Phytochemistry and Pharmacological Properties of *Terminalia spinosa* Engl.: A Comprehensive Review

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Abstract

Terminalia spinosa Engl. is a shrub or small tree widely used as a source of traditional medicines in tropical Africa. This study was aimed at reviewing the medicinal uses, phytochemical and pharmacological properties of *T. spinosa*. A search for available information on the medicinal uses, phytochemical and pharmacological properties of *T. spinosa* was conducted by searching the electronic databases which included SciELO, ScienceDirect®, Web of Science, PubMed®, SpringerLink®, Scopus® and Google Scholar, as well as pre-electronic literature sources such as books, book chapters and other scientific publications obtained from the university library. This research revealed that the bark, fibres, leaves, roots or stem bark of *T. spinosa* are used as traditional medicines for wounds, fever, jaundice, malaria, sore throat and stomach ailments. The phytochemical evaluation of the plant species revealed that it contains flavonoids, fatty acids, anthocyanins, coumarins, ellagic acid, polyphenols, anthraquinone, tannins, polysaccharides, steroids and triterpenoids. The pharmacological evaluations showed that the crude extracts of *T. spinosa* have antibacterial, anti-Neisseria gonorrhoeae, antimycobacterial, antifungal, antiplasmodial and antiproliferative activities. To realize the full potential of *T. spinosa* as traditional medicine, future studies should focus on conducting detailed phytochemical, pharmacological and toxicological evaluations, *in vivo* and clinical research.

Key words: Bush willow family, combretaceae, indigenous knowledge, materia medica, *Terminalia spinosa*

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Terminalia spinosa Engl. (Fig. 1) is a member of the Combretaceae family commonly known as the white mangrove, Indian almond or bush willow family. Combretaceae family consists of about 530 species belonging to ten genera, including *Combretum* Loefl., *Conocarpus* L., *Dansiea* Bymes, *Getonia* Roxb., *Guiera* Adans. ex Juss., *Laguncularia* C.F.Gaertn., *Lumnitzera* Willd., *Macropteranthes* F.Muell., *Strephonema* Hook.f. and *Terminalia* L.[1-3]. Majority of the plants belonging to the Combretaceae family are woody, mostly trees, shrubs or lianes[4,5]. The socio-economic, cultural and medicinal importance of the *Terminalia* genus has been recorded throughout the world[6-16]. Some of the *Terminalia* species that are used as traditional medicines include *T. arjuna* (Roxb. ex DC.) Wight and Arn., *T. avicennioides* Guill. and Perr., *T. bellirica* (Gaertn.) Roxb., *T. bentzoë* (L.) L.f., *T. brachystemma* Welw. ex Hiern, *T. Brownii* Fresen., *T. chebula* Retz., *T. Laxiflora* Engl. and Diels, *T. macroptera* Guill. and Perr., *T. phanerophlebia* Engl. and Diels, *T. schimperiana* Hochst. and *T. spinosa* Engl.[13,15-18]. Researchers attribute the medicinal properties of the Terminalia species to various active constituents, including tannins, triterpenes, phenols, glycosides, steroids, polyols, esters, styrenes, saponins, anthraquinones, flavonoids and lignans[13,15,16]. In addition to medicinal applications, the bark, fruit, leaf and root extracts of several *Terminalia* species are widely used to produce various colours of dyes[14,17,19]. *Terminalia spinosa* is a multipurpose species[20-23], which exudes edible gum[20-22,24], source of yellow dye[25], green manure[24], flowers used for insect foraging[25,26] and considered to be a valuable medicinal plant in tropical Africa[13,15,16,18,27]. *Terminalia spinosa* has preservative properties and is applied to fresh skins of slaughtered animals to prevent them from rotting[28]. *Terminalia spinosa* is grown in private gardens throughout its distributional range for shade, live fence and as an ornamental[23,25,26,29]. The species is an important source of charcoal, firewood, browse and fodder[20,22-25]. The bark, fruits, leaves or shoots are eaten by giraffe, goats, elephants and game[20,22,24,25] and in Somalia, *T. spinosa* is a major forage plant species in camel diets in both the dry and wet seasons[30]. Similarly, the wood of *T. spinosa* is brown in colour, fairly heavy and hard with a coarse grain, easily worked, durable, termite resistant and makes a useful general-purpose timber as construction material for houses, livestock enclosures, fencing posts, yokes, pestles, roofs, handles of agricultural implements, furniture and ornaments[20,22-25,29,31]. It is therefore against this background that the current study was undertaken, aimed at reviewing the importance of *T. spinosa* in traditional medicine and evaluating its phytochemical and pharmacological properties.

MATERIALS AND METHODS

The literature search for medicinal uses, phytochemical and pharmacological properties of *T. spinosa* was conducted from July to November, 2024 using online search databases used including Web of Science, Scopus®, SpringerLink®, Google Scholar, SciELO, PubMed® and ScienceDirect®. Pre-electronic sources, including books, book chapters, journal articles, dissertations and thesis, obtained from the University library, were also used. The keywords used in the search included "*Terminalia spinosa*" and English common names "spiny cluster leaf", "spiny desert tree" and "spiny terminalia". An additional search was also conducted using the keywords "Biological activities of *Terminalia spinosa*", "Pharmacological properties of *Terminalia spinosa*", "Ethnobotany of *Terminalia spinosa*", "Medicinal uses of *Terminalia spinosa*", "Phytochemistry of *Terminalia spinosa*" and "Traditional uses of *Terminalia spinosa".* The search covered publications from 1961 to 2024, a long period to capture literature on the medicinal uses, phytochemical and pharmacological properties of *T. spinosa*.

RESULTS AND DISCUSSION

Taxonomy and morphological description of *Terminalia spinose*: The genus *Terminalia* consists of approximately 300 species and is fairly cosmopolitan in distribution, recorded across the tropical areas of Asia, Africa, America and extending into the subtropical regions of the Pacific Islands and Australia[4,5,12,32,33]. The genus *Terminalia* comprises trees, shrubs and lianas, characterized by the leaves which are simple, without scales, that are alternate, spirally arranged or sometimes opposite or nearly opposite and are usually terminal or crowded towards the ends of the branches and sometimes on short shoots[4,5,33]. The leaves of some *Terminalia* species are petiolate or subsessile, usually entire but occasionally subcrenata, often with some pellucid dots or glands on either side of the leaf near the base or on the petiole[31]. The flowers are bisexual or male or female on the same or different trees, usually borne in lax spikes[34]. The flowers are small, lacking petals and the fruit is one-seeded with two wings which are joined at the top and bottom[34]. The bark, leaf and fruit characters are widely used to differentiate and identify the

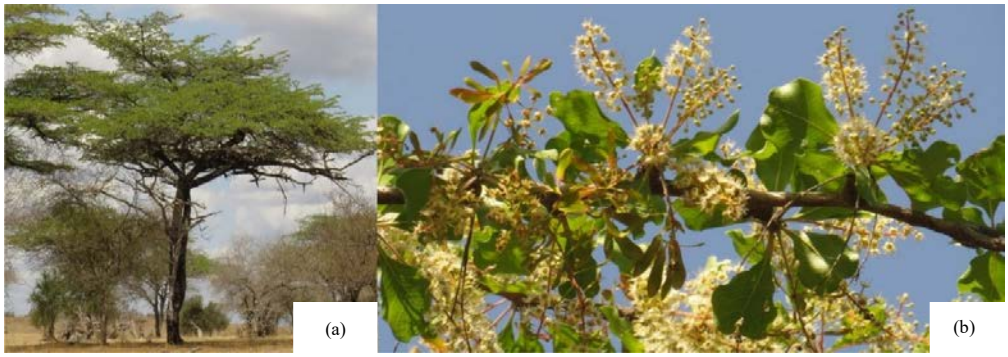

Fig. 1(a-b): *Terminalia* spinose, (a) Entire plant and (b) Branch showing leaves and flowers (photos: Joachim Louis)

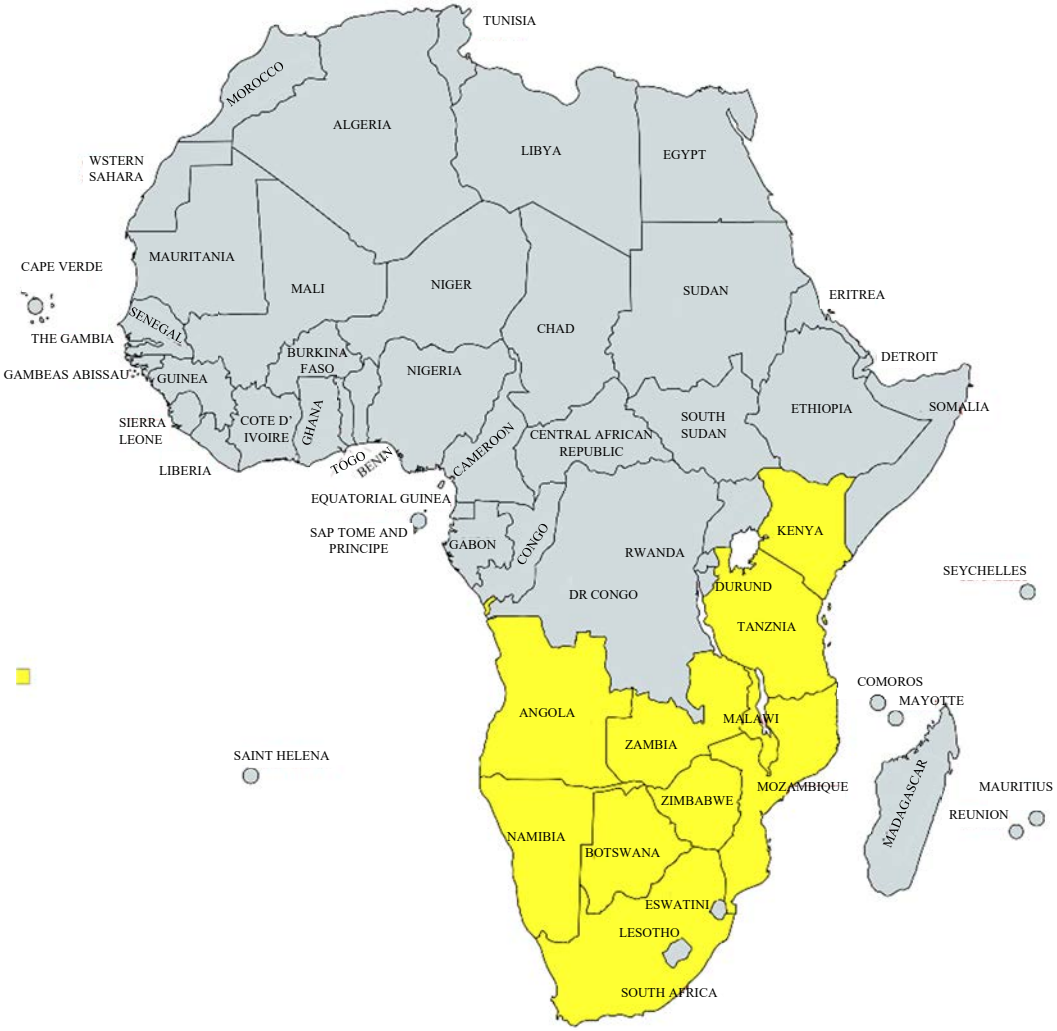

Fig. 2: Distribution of *Terminalia spinosa* in tropical Africa

Terminalia species[33-36]. The genus name *Terminalia* is derived from the Latin word "*terminus*" which means "end", about the leaves that are borne in whorls close to ends of the shoots, branchlets and branches[27]. The specific name "*spinosa*" is based on the Latin word "spinosus" meaning "spiny" or "thorny" in reference to the species having spines[34]. The English common names of *T. spinosa* include "spiny cluster leaf", "spiny desert tree" and "spiny terminalia"[26,37]. The synonyms of *T. spinosa* include *Bucida correlliana* Northr[27,38].

Terminalia spinosa is a shrub or small deciduous spiny tree (Fig. 1a) growing up to 20 m in height[26,38,39]. The stem is upright or crooked, characterized by zig-zag shoots or the branches in distinct horizontal layers or planes[26]. The bark is grey to dark grey or blackish, rough, longitudinally fissured and with splitting ridges. The leaves are scattered, but they tend to be crowded towards the ends of the branches or shoots. The leaves are light green, grey-green to dark green, margins entire, rounded at the apex, clearly notched and narrowing to a short stalk. The flowers are white to pink in colour (Fig. 1b), occurring in long lax spikes, in clusters beside the leaves. The fruit is winged, wind-dispersed, oval in shape orange or purple-brown to dark brown at maturity[26,39,40]. *Terminalia spinose* has been recorded in Ethiopia, Kenya, Somalia, South Sudan, Sudan, Tanzania and Uganda[38,39,41,42] (Fig. 2). *Terminalia spinosa* has been recorded in dry coastal forests, bushland, wooded grassland in sandy, clay alluvial soils and on rocky areas, well-drained soils in disturbed areas, open savanna and forest ecotone zones at an altitude ranging from sea level to 1800 m above sea level[26,39,40]. *Terminalia spinose* is a well-known pioneer species, successful at colonizing undulating degraded terrain by trampling and grazing[40]. In some areas where forests or woodlands have been cleared, *T. spinosa* seems to be the first woody species to recolonize such habitats, perhaps restoring the shade and nutrient conditions needed for the establishment of the climax community[40].

Medicinal uses of *Terminalia spinose*: The crude extracts of *T. spinose* are used as a source of traditional medicines in Tanzania, Ethiopia, Somalia and Kenya, that is, 57.1% of the countries where *T. spinosa* is indigenous (Table 1). The herbal medicines which are prepared from the fibres, bark, roots, leaves and stem bark of *T. spinosa* are used to treat and manage 12 human and animal diseases and ailments. In Ethiopia, the root decoction of *T. spinosa* is applied topically as a remedy for eye problems[43] while leaf or stem bark decoction is applied topically against wounds in Tanzania[44-46]. In Somalia, the fibre or root decoction of *T. spinosa* is used as ethnoveterinary medicine for ear or nasal inflammation[47]. In Kenya, the roots of *T. spinosa* are used as charm against witchcraft[29,48] or bark or stem bark decoction as traditional medicine for jaundice[12,26,27,39,49], sore throat[25,49] and stomach ailments[48,49]. In Kenya, the bark of *T. spinosa* is often mixed with that of *Zanthoxylum chalybeum* Engl. (Rutaceae family) and taken orally as traditional medicine for both fever and malaria[27,44-46,49-57]. Other medicinal applications of *T. spinose* include the use of bark, leaf or root decoction as traditional medicine for hernia or retained placenta[27].

Phytochemistry and pharmacological properties of *Terminalia spinosa*: Qualitative and quantitative phytochemical analyses of *T. spinosa* heartwood, leaves and stem bark revealed the presence of flavonoids, fatty acids, anthocyanins, coumarins, ellagic acid, polyphenols, anthraquinone, tannins, polysaccharides, steroids and triterpenoids[27,46,50] (Table 2). Some of the phytochemical compounds isolated from *T. spinosa* and its crude extracts exhibited antibacterial, anti-Neisseria gonorrhoeae, antimycobacterial, antifungal, antiplasmodial and antiproliferative activities.

Antibacterial activities: Fabry *et al.*[57] evaluated the antibacterial activities of aqueous extract of *T. spinose* stem bark and young branches against Helicobacter pylori using the microtitre serial dilution technique. The extract exhibited activities against the tested pathogen, exhibiting the minimum inhibitory concentration (MIC) values ranging from 62.5 mg/mL to 500.0 mg/mL[57]. Fabry *et al.*[58] evaluated the antibacterial activities of aqueous extracts of the young branches of *T. spinosa* against *Staphylococcus aureus, Enterococcus* spp., *Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella* spp., *Salmonella* spp. and *Mycobacterium* spp. using the microtitre serial dilution technique. The extract exhibited activities against the tested pathogens, exhibiting the MIC values ranging from 0.03 to 8.0 mg/mL[58]. Mbwambo *et al.*[59] evaluated the antibacterial activities of acetone, ethanol and dichloromethane: methanol (1:1) extracts of *T. spinosa* roots and stem bark against *Mycobacterium madagascariense*, *Mycobacterium indicus pranii*, *Staphylococcus aureus*, *Streptococcus faecalis*, *Vibrio cholerae*, *Bacillus subtilis*, *Bacillus anthracis*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Salmonella typhi* and *Escherichia coli* using the microdilution method with gentamicin as a positive control. The extracts exhibited activities against the tested pathogens, exhibiting MIC values ranging from 0.31 to 5.0 mg/mL[59].

Anti-Neisseria gonorrhoeae activities: da Silva *et al.*[60] evaluated the anti-Neisseria gonorrhoeae activities of ethanol extracts of *T. spinosa* leaves and roots against nine Neisseria *gonorrhoeae* penicillin and tetracycline-sensitive and resistant strains using the agar dilution assay. The extracts demonstrated activities against the tested pathogens, exhibiting MIC values ranging from 100.0 to 400.0 µg/mL[60].

Table 1: Medicinal uses of *Terminalia spinosa*

Medicinal use	Parts used	Country	References
Mono-therapeutic applications			
Charm against witchcraft	Roots	Kenya	Pakia *et al.*[29,48]
Eye problems	Root decoction applied topically	Ethiopia	Gobana *et al.*[43]
Fever	Bark or stem bark chewed or decoction taken orally	Kenya and Tanzania	Cock[12], Kipkore *et al.*[37], Chhabra *et al.*[44], Kokwaro[45], Fyhrquist *et al.*[46] and Omulokoli *et al.*[50]
Hernia	Leaf or root decoction taken orally	Not specified	Quattrocchi[27]
Jaundice	Bark or stem bark decoction taken orally	Kenya	Cock[12], Dharani[26], Quattrocchi[27], Beentje[39] and Mutie *et al.*[49]
Malaria	Bark, leaf or stem bark decoction taken orally	Kenya and Tanzania	Quattrocchi[27], Kipkore *et al.*[37], Chhabra *et al.*[44], Kokwaro[45], Fyhrquist *et al.*[46], Mutie *et al.*[49], Omulokoli *et al.*[50], Fyhrquist *et al.*[51], Muthaura *et al.*[52], Nguta *et al.*[53], Gafna *et al.*[54], Omara[55] and Kacholi[56]
Retained placenta	Bark decoction taken orally	Not specified	Quattrocchi[27]
Sore throat	Bark chewed	Kenya	Medley and Kalibo[25] and Mutie *et al.*[49]
Stomach ailments	Root decoction taken orally	Kenya	Pakia and Cooke[48] and Mutie *et al.*[49]
Wounds	Leaf or stem bark decoction applied topically	Tanzania	Chhabra *et al.*[44], Kokwaro[45] and Fyhrquist *et al.*[46]
Ethnoveterinary medicine			
Ear inflammation	Root decoction used as ear drop	Somalia	Yusuf-Isleged *et al.*[47]
Nasal inflammation	Fibre or root decoction used as nasal drop	Somalia	Yusuf-Isleged *et al.*[47]
Used in combination with other species			
Fever or malaria	Bark mixed with that of *Zanthoxylum chalybeum* Engl. (Rutaceae family) and administered as a decoction	Kenya	Kipkore *et al.*[37]

Table 2: Phytochemical composition of *Terminalia spinosa*

Phytochemical compound	Plant part	References
Anthocyanins	Stem bark	Omulokoli *et al.*[50]
Coumarins	Leaves and stem bark	Omulokoli *et al.*[50] and Fyhrquist *et al.*[46]
Ellagic acid glycoside	Leaves	Fyhrquist *et al.*[46]
Ellagitannins	Leaves	Fyhrquist *et al.*[46]
Emodins	Stem bark	Omulokoli *et al.*[50]
Flavonoids	Stem bark	Omulokoli *et al.*[50]
Gallic acid	Leaves	Fyhrquist *et al.*[46]
Gallotannins	Leaves	Fyhrquist *et al.*[46]
Palmitic acid	Heartwood	Quattrocchi[27]
Polyoses	Stem bark	Omulokoli *et al.*[50]
Polyuronides	Stem bark	Omulokoli *et al.*[50]
Stearic acid	Heartwood	Quattrocchi[27]
Steroids	Stem bark	Omulokoli *et al.*[50]
Triterpenoids	Stem bark	Omulokoli *et al.*[50]
Tannins	Leaves and stem bark	Omulokoli *et al.*[50] and Fyhrquist *et al.*[46]

Antimycobacterial activities: Fyhrquist *et al.*[46] evaluated the antimycobacterial activities of water, butanol and chloroform extracts of *T. spinosa* leaves against *Mycobacterium smegmatis* using the agar diffusion method with rifampicin as a positive control. The extracts exhibited activities against the tested pathogen, exhibiting zone of inhibition ranging from 17.0 to 23.0 mm[46].

Antifungal activities: Fabry *et al.*[28] evaluated the antifungal activities of aqueous extracts of the young branches of *T. spinosa* against *Candida albicans*, *Candida tropicalis*, *Candida parapsilosis*, *Candida glabrata*, *Candida guilliermondii*, *Candida krusei*, and *Aspergillus* spp. using the microtitre serial dilution technique. The extract demonstrated activities against the tested pathogens, exhibiting the MIC values ranging from 0.003 to 8.0 mg/mL[28]. Fyhrquist *et al.*[51] evaluated the antifungal activities of the methanol extract of *T. spinosa* leaves against *Candida tropicalis* and *Candida krusei* using the agar diffusion method with amphotericin B and itraconazole as positive controls. The extracts demonstrated activities against *Candida tropicalis* and *Candida krusei,* exhibiting zone of inhibition of 15.9 and 17.5 mm, respectively[51].

Antiplasmodial activities: Omulokoli *et al.*[50] evaluated the antiplasmodial activities of the aqueous and methanolic extracts of *T. spinosa* stem bark and stem wood against the chloroquine-resistant (ENT36) and chloroquine-sensitive (K67)

strains of *Plasmodium falciparum* using the [G-^{3}H] hypoxanthine incorporation assay with chloroquine as a positive control. The extracts showed activities exhibiting the half maximal inhibitory concentration (IC_{50}) values which ranged from 9.9 to 49.2 µg/mL[50].

Antiproliferative activities: Fyhrquist *et al.*[61] evaluated the antiproliferative activities of the methanolic extract of *T. spinosa* leaves against T 24 (bladder carcinoma) cancer cell lines using the Alamar Blue assay. The extract demonstrated activities against T 24, exhibiting inhibition of 44.9%[61].

CONCLUSION

Terminalia spinosa demonstrates broad ethnomedicinal applications across East African countries, notably Tanzania, Ethiopia, Somalia and Kenya, where it is traditionally used to treat conditions such as fever, malaria, sore throat, wounds, stomach disorders and in ethnoveterinary practices. While these traditional uses are promising, there remains a critical need for comprehensive pharmacological validation. Future research should focus on confirming its phytochemical constituents, elucidating mechanisms of action *in vivo*, assessing toxicity and safety profiles and conducting clinical trials. Additionally, evaluating potential synergistic effects with other medicinal plants, such as *Ziziphus chalybeum*, could further support and expand its therapeutic relevance.

SIGNIFICANCE STATEMENT

The current study contributes to the existing traditional knowledge about medicinal applications of *T. spinosa* that could be useful in bio-prospecting for new health-promoting and pharmaceutical products. Documentation of medicinal uses and phytochemical and pharmacological properties of *T. spinosa* is an essential step towards the identification of knowledge gaps required to correlate the ethnopharmacological properties of the species. Therefore, future research on the species should focus on conducting detailed phytochemical and pharmacological studies and also evaluating toxicological properties, *in vivo* and clinical studies.

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